APPENDIX A

"CLEAN" VERSION OF EACH PARAGRAPH/SECTION/CLAIM
37 C.F.R. § 1.121(b)(ii) AND (c)(i)

CLAIMS:

B/C AC

1 ~~10.~~ (Amended) A method of joining a substrate electrode formed on a substrate and a device electrode formed on a device to each other by solder to mount said device on said substrate, the method comprising:

attaching a solder piece to said substrate electrode;

melting said solder piece while said solder piece is at least partially submerged in a liquid to form a solder bump having an adhered surface and an opposite surface;

positioning said device electrode so as to contact said opposite surface of said solder bump such that the center of said device electrode is not aligned with the center of said substrate electrode while said device is at least partially submerged in said liquid;

aligning the center of said device electrode with the center of said substrate electrode by surface tension of said solder bump when said solder bump is melted and while said device is at least partially supported by a buoyant force thereby joining said device electrode and said substrate electrode to each other; and

solidifying said solder bump.

B/C Ac

15 ~~27.~~ (New) A method of joining a device to a substrate having a solder piece electrically coupled to an electrode of the substrate, the method comprising:

placing the substrate in a liquid;

melting the solder piece to form a solder bump while the substrate is in the liquid;

placing a device having a device electrode on the solder bump while the device is in the liquid such that the device electrode is out of alignment with the substrate electrode;

melting the solder bump so as to cause the device electrode to align with the substrate electrode while the device and the substrate are in the liquid.

16 15

~~28~~. (New) The method as claimed in claim ~~27~~, wherein a center of the device electrode is out of alignment with a center of the substrate electrode during the placing of the device on the solder bump.

17 16

~~29~~. (New) The method as claimed in claim ~~28~~, wherein the device is buoyantly supported by the liquid during the melting of the solder bump.

18 17

~~30~~. (New) The method as claimed in claim ~~29~~, wherein the center of the device electrode and the center of the substrate electrode are aligned with each other during the melting of the solder bump.

19 15

~~31~~. (New) The method as claimed in claim ~~27~~, further comprising:

applying a vibration to the solder piece during the melting thereof.

20 19

~~32~~. (New) The method as claimed in claim ~~31~~, wherein the vibration is an ultrasonic vibration.

21 19

~~33~~. (New) The method as claimed in claim ~~31~~, wherein the vibration is applied to the solder piece through the liquid.

22 19

~~34~~. (New) The method as claimed in claim ~~31~~, wherein the vibration is applied to the solder piece in an amount sufficient to break an oxide film formed on the surface of the solder piece.

23 19

~~35~~. (New) The method as claimed in claim ~~31~~, further comprising:

applying a vibration to the solder bump during the melting thereof.

24 23

~~36~~. (New) The method as claimed in claim ~~35~~, wherein the vibration is an ultrasonic vibration.

25 23

~~37~~. (New) The method as claimed in claim ~~35~~, wherein the vibration is applied to the solder bump through the liquid.

26 23

~~38~~. (New) The method as claimed in claim ~~35~~, wherein the vibration is applied to the solder bump in an amount sufficient to break an oxide film formed on the surface of the solder bump.

27 23

~~39~~. (New) The method as claimed in claim ~~35~~, wherein the vibration is applied to the solder bump in an amount sufficient to increase a surface tension of the solder bump.

28 27

~~40~~. (New) The method as claimed in claim ~~39~~, wherein the amount of vibration applied to the solder bump is sufficient to cause the surface tension of the solder bump to reach a maximum.

29 23

~~41~~. (New) The method as claimed in claim ~~35~~, wherein the vibration is applied to the solder bump in an amount sufficient to deform the solder bump.

30 29

~~42~~. (New) The method as claimed in claim ~~41~~, wherein the deformation of the solder bump causes the alignment of the device electrode with the substrate electrode.

31 15

~~43~~. (New) The method as claimed in claim ~~27~~, further comprising:

solidifying the solder bump to fix the device to the substrate.

32 15

~~44~~. (New) The method as claimed in claim ~~27~~, wherein the liquid is inactive to the device and the substrate.

33 15

~~45~~. (New) The method as claimed in claim ~~27~~, wherein the device is an optical device.

34 ~~46.~~ (New) The method as claimed in claim 15 ~~27~~, wherein the device is a semiconductor device.

35 ~~47.~~ (New) The method as claimed in claim 15 ~~27~~, wherein the substrate is a semiconductor substrate.

36 ~~48.~~ (New) The method as claimed in claim 15 ~~27~~, wherein the substrate is a substrate for mounting an electric element.

37 ~~49.~~ (New) The method as claimed in claim 15 ~~27~~, wherein the substrate is a ceramic substrate.

38 ~~50.~~ (New) The method as claimed in claim 15 ~~27~~, wherein the substrate is a printed circuit board.

APPENDIX B

VERSION WITH MARKINGS TO SHOW CHANGES MADE
37 C.F.R. § 1.121(b)(iii) AND (c)(ii)

CLAIMS:

10. (Amended) A method of joining a substrate electrode formed on a substrate and a device electrode formed on a device to each other by solder to mount said device on said substrate, the method comprising [the steps of]:

attaching a solder piece to said substrate electrode;

melting said solder piece while said solder piece is at least partially submerged in a liquid to form a solder bump having an adhered surface and an opposite surface;

[pre-]positioning said device electrode so as to contact said opposite surface of said solder bump such that the center of said device electrode is not aligned with the center of said substrate electrode while said device is at least partially submerged in said liquid;

[positioning] aligning the center of said device electrode [to] with the center of said substrate electrode by surface tension of said solder bump when said solder bump is melted and while said device is at least partially submerged in said liquid and at least partially supported by a buoyant force thereby joining said device electrode and said substrate electrode to each other; and [then]

solidifying said solder bump.

APPENDIX C

COMPLETE CLEAN SET OF PENDING CLAIMS

37 C.F.R. § 1.121(c)(iii)

CLAIMS:

10. A method of joining a substrate electrode formed on a substrate and a device electrode formed on a device to each other by solder to mount said device on said substrate, the method comprising:

attaching a solder piece to said substrate electrode;

melting said solder piece while said solder piece is at least partially submerged in a liquid to form a solder bump having an adhered surface and an opposite surface;

positioning said device electrode so as to contact said opposite surface of said solder bump such that the center of said device electrode is not aligned with the center of said substrate electrode while said device is at least partially submerged in said liquid;

aligning the center of said device electrode with the center of said substrate electrode by surface tension of said solder bump when said solder bump is melted and while said device is at least partially submerged in said liquid and at least partially supported by a buoyant force thereby joining said device electrode and said substrate electrode to each other; and

solidifying said solder bump.

11. The method as claimed in claim 10, wherein as said solder piece is melted to form said solder bump, a vibration is applied to said solder piece while said solder piece is at least partially submerged in said liquid.

12. The method as claimed in claim 10, wherein when said solder bump is melted while said solder bump is at least partially submerged in said liquid to join said device electrode and said substrate electrode to each other, a vibration is applied to said solder bump while said device is at least partially submerged in said liquid.

13. The method as claimed in claim 10, wherein said liquid is inactive to said solder, said device and said substrate.

14. The method as claimed in claim 10, wherein said device is an optical device.

15. The method as claimed in claim 10, wherein said device is a semiconductor device.

16. The method as claimed in claim 10, wherein said substrate is a semiconductor substrate.

17. The method as claimed in claim 10, wherein said substrate is a substrate for mounting an electric element.

18. The method as claimed in claim 10, wherein said substrate is a ceramic substrate.

19. The method as claimed in claim 10, wherein said substrate is a printed circuit board.

21. The method as claimed in claim 11, wherein said vibration is applied ultrasonically.

22. The method as claimed in claim 12, wherein said vibration is applied ultrasonically.

25. The method as claimed in claim 22, wherein said vibration is applied ultrasonically through said liquid to said solder bump disposed in said liquid.

26. The method as claimed in claim 25, wherein an oxide film on the surface of said solder bump is broken to enhance the surface tension when said solder bump is melted.

27. A method of joining a device to a substrate having a solder piece electrically coupled to an electrode of the substrate, the method comprising:

placing the substrate in a liquid;

melting the solder piece to form a solder bump while the substrate is in the liquid;

placing a device having a device electrode on the solder bump while the device is in the liquid such that the device electrode is out of alignment with the substrate electrode;

melting the solder bump so as to cause the device electrode to align with the substrate electrode while the device and the substrate are in the liquid.

28. The method as claimed in claim 27, wherein a center of the device electrode is out of alignment with a center of the substrate electrode during the placing of the device on the solder bump.

29. The method as claimed in claim 28, wherein the device is buoyantly supported by the liquid during the melting of the solder bump.

30. The method as claimed in claim 29, wherein the center of the device electrode and the center of the substrate electrode are aligned with each other during the melting of the solder bump.

31. The method as claimed in claim 27, further comprising:

applying a vibration to the solder piece during the melting thereof.

32. The method as claimed in claim 31, wherein the vibration is an ultrasonic vibration.

33. The method as claimed in claim 31, wherein the vibration is applied to the solder piece through the liquid.

34. The method as claimed in claim 31, wherein the vibration is applied to the solder piece in an amount sufficient to break an oxide film formed on the surface of the solder piece.

35. The method as claimed in claim 31, further comprising:
applying a vibration to the solder bump during the melting thereof.

36. The method as claimed in claim 35, wherein the vibration is an ultrasonic vibration.

37. The method as claimed in claim 35, wherein the vibration is applied to the solder bump through the liquid.

38. The method as claimed in claim 35, wherein the vibration is applied to the solder bump in an amount sufficient to break an oxide film formed on the surface of the solder bump.

39. The method as claimed in claim 35, wherein the vibration is applied to the solder bump in an amount sufficient to increase a surface tension of the solder bump.

40. The method as claimed in claim 39, wherein the amount of vibration applied to the solder bump is sufficient to cause the surface tension of the solder bump to reach a maximum.

41. The method as claimed in claim 35, wherein the vibration is applied to the solder bump in an amount sufficient to deform the solder bump.

42. The method as claimed in claim 41, wherein the deformation of the solder bump causes the alignment of the device electrode with the substrate electrode.

43. The method as claimed in claim 27, further comprising:
solidifying the solder bump to fix the device to the substrate.

44. The method as claimed in claim 27, wherein the liquid is inactive to the device and the substrate.

45. The method as claimed in claim 27, wherein the device is an optical device.

46. The method as claimed in claim 27, wherein the device is a semiconductor device.

47. The method as claimed in claim 27, wherein the substrate is a semiconductor substrate.

48. The method as claimed in claim 27, wherein the substrate is a substrate for mounting an electric element.

49. The method as claimed in claim 27, wherein the substrate is a ceramic substrate.

50. The method as claimed in claim 27, wherein the substrate is a printed circuit board.

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(54) Title of Invention: A Mounting Method Using Solder of the Eutectic System.

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Specification

1. Title of Invention: A Mounting Method Using Solder of the Eutectic System

2. Scope of Claim for Patent:

A mounting method using a solder of the eutectic system, characterized in that a eutectic alloy is held between a semiconductor element and a substrate to be compressively held by means of the upper and lower jigs, all these being immersed in saturated vapor or heated inert solvent which is obtained by heating the inert solvent and said semiconductor element and substrate are eutectically diffused and united by dissolving

the eutectic alloy.

3. Detailed Explanation of the Invention:

(Field of Industrial Utilization)

This invention relates to a mounting method employing a solder of the eutectic system in connection with the fixing of a semiconductor element to the substrate.

(Technology According To Prior Art)

According to prior art technology, such a semiconductor element as GaAs, etc. is fixed to the substrate by Si, etc. in the following manner:

As is shown in Figure 4, a eutetic alloy 4 is held between a semiconductor element 2 that has been formed by sputtering and given a metallization treatment and the substrate to be pressurized and heated by being held between upper and lower jigs 5 and 6, thereby making it possible for the semiconductor element 2 and the substrate 3 to be joined through the eutetic alloy.

In the case of such joining, the joining and fixing treatment has been carried out in the atmosphere of such an inert gas as N2 or Ar, to cite an example.

(Problem To Be Solved By The Invention)

The above-described conventional mounting method using a eutectic alloy has had the following shortcomings:

Although the fixing treatment is carried out in the atmosphere of an inert gas, oxidation takes place due to the heating of the upper and lower jigs 5 and 6 and it is not only difficult to manage the temperature of the upper and lower jigs 5 and 6 but heat conduction is not carried out uniformly as heating is effected from one side of the semiconductor element 2 and substrate 3, thereby creating variations in temperature, which leads to joining failure or inability to get a satisfactory joined state in a short period

of time.

This invention was culminated in view of the aforementioned circumstances. Its purpose lies in offering a mounting method employing a solder of the eutectic system, in which no oxidation takes place, temperature management is easy to carry out, with uniformalized heat conductance, making it possible to achieve a satisfactorily joined state in a short period of time.

(Means For Solving The Problem)

For the purpose of solving the aforesaid problem, the mounting method employing a solder of the eutectic system according to this invention is characterized in that a eutectic alloy is held between a semiconductor element and a substrate to be compressively held by means of an upper and lower jigs, all these being immersed in saturated vapor or heated inert solvent which is obtained by heating the inert solvent and said semiconductor element and substrate are eutectically diffused and united by dissolving the eutectic alloy.

(Function)

According to the mounting method using a solder of the eutectic system as described above, there is no oxidation as eutectic diffusion and joining are carried out in the saturated vapor layer of fluorinated inert solvent or in a heated inert solvent, with the temperature being held lower than the boiling point of the solvent, thereby making heat management easier to enforce and eliminating the variations in the temperature of the eutectic alloy. Heat conductance is carried out not from one side but from all sides, thereby making it possible to effect heat conductance in a short

period of time and causing the semiconductor element to be tightly joined to the substrate.

(Examples)

Below, some examples of the mounting method using the solder of the eutectic system according to this invention will be explained in detail by referring to the attached drawings.

Figure 1 shows the state of the arrangement of the semiconductor element and substrate, etc. in an example of this invention. Figures 2 and 3 indicate the state of joining in saturated vapor and in a solvent.

In Figure 1, a solder 12 of the eutectic system made of a eutectic alloy is arranged between a semiconductor element 10 that has been formed by sputtering and metallized and a substrate 13. Next, the semiconductor element 10 and the substrate 13 are held and pressurized between the upper and lower jigs 14 and 15.

Subsequent to being constituted in the manner described above, the entirety is then arranged in saturated vapor Va which is generated by heating the container M of a fluorinated inert solvent P as is shown in Figure 2.

According to such a mounting method in saturated vapor Va, the heat of the saturated vapor Va of the fluorinated inert solvent P reaches the entire surfaces, with a consequence that heat absorption is carried out on the whole, with the eutectic alloy 12 between the semiconductor element 10 and the substrate 13 being dissolved, thereby making it possible for

eutectic diffusion and joining to be effected.

In the above case, there is no oxidation as compared with the case where the heating jigs 14 and 15 are heated. As the temperature does not rise above the boiling point of the fluorinated inert solvent P, moreover, the management of the temperature due to the difference in the eutectic alloy 12 or the difference in the size of the semiconductor element 10 and the substrate 13, etc. becomes easier.

In this manner, the joining of the semiconductor element 10 and the substrate 13 is carried out through the eutectic alloy 12 by means of a heat exchange of the condensation heat of the heat medium.

In another example, it becomes possible to immerse them in a fluorinated inert solvent P as is shown in Figure 3, thereby carrying out the eutectic diffusion joining of the semiconductor element 10 and the substrate 13 as described above. In the state of such joining, too, a functional effect which is the same as described above is also obtained.

Since the fluorinated inert solvent is used in each of the aforementioned examples, it can be used even in the atmosphere. This is highly advantageous as compared with the large apparatus using an inert gas according to prior art.

(Effect of the Invention)

According to the mounting method using a solder of the eutectic system as described in the invention above, the eutectic alloy is held between a semiconductor element and the substrate to be held under pressurization

by means of the upper and lower jigs, with all of these being immersed in saturated vapor or heated inert solvent that is obtained by the heating treatment of the inert solvent, and said semiconductor element and substrate are eutectically diffused and joined by dissolving the eutectic alloy, with a consequence that there is produced no oxidation, the temperature control becomes easier to carry out and the heat conductance is uniformalized, thereby making it possible to achieve the joined state between the semiconductor element and the substrate in a short period of time.

4. Concise Explanation of the Drawings:

Figure 1 is a figure shown for the purpose of explaining the mounting method employing a solder of the eutectic system according to this invention. Figure 2 is a figure shown for explaining the joining in saturated vapor. Figure 3 is an explanatory figure showing the joining state when immersed in a solvent. Figure 4 is shown for explaining the mounting method using a solder of the eutectic system according to an example of prior art.

10. Semiconductor element

12. Solder of the eutectic system

13. Substrate

14 and 15. Upper and lower jigs

P. Inert solvent

Va. Saturated vapor

(Insert Figures 1, 2, 3 and 4 on p. 201.)

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